



WW: DY Estimation, Met Efficiency and JEC in 38X data/MC

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Outline

- List of datasets
- DY estimation for WW
- MET selection efficiencies in WW
- Jet response in 38X data/MC using the Z+1 jet events

Datasets

- **Data**
 - **15/pb data corresponds to:** /afs/cern.ch/user/s/slava77/public/jsons/oct22/special/Cert_Topoct22_Merged_I35821-I48058_allPVT.txt
- **38X MC for DY estimation and JEC studies**
 - /DYToEE_M-20_TuneZ2_7TeV-pythia6_Fall10-START38_V12-v1/
 - /DYToMuMu_M-20_TuneZ2_7TeV-pythia6_Fall10-START38_V12-v1/
- **36X MC for Met efficiency comparisons**
 - Pythia: /WWTo2L2Nu_7TeV-pythia6_Spring10-START3X_V26-v1
 - Madgraph: /VVJets-madgraph_Spring10-START3X_V26_S09-v1
 - MC@NLO: /WWtoEE-mcatnlo_Spring10-START3X_V26_S09-v1

DY Estimation

Drell Yan Estimation (1/2)

- Data driven method to predict DY in EE/MM (AN-2009/023)

- Use the events inside the Z window to predict the value outside
- The ratio $R_{out/in}$ are obtained through MC

$$N_{DY}^{out \ (est)} = \frac{N_{DY \ DATA}^{in}}{N_{DY \ MC}^{in}} \cdot N_{DY \ MC}^{out}$$

$$N_{DY}^{out \ (est)} = N_{DY \ DATA}^{in} \cdot R_{out/in}$$

- Use the EM yields to predict the non-peaking background

$$N_{DY/ZZ}^{out \ (est)} = (N_{ll \ DATA}^{in} - k \cdot N_{e\mu \ DATA}^{in}) \cdot R_{out/in}$$

- Test on the events without MET, see good agreement

Table 2: Drell-Yan estimation with no MET Cut.

Sample	ee	$\mu\mu$
$R_{out/in}$	0.09 ± 0.00	0.10 ± 0.00
MC Prediction	278.58 ± 1.71	425.79 ± 2.06
Data Driven DY Estimate	295.63 ± 5.56	481.32 ± 7.37
Actual Yield in Data	316	491

Drell Yan Estimation (2/2)

- Rout/in is sensitive to MET cut**

- Events with large projected MET are statistically limited
- We see large variations of R(out/in) with different of MET cut (similar behavior using pfMet in slide 20)
- The conservative approach: use the largest spread of Rout/in as the systematic error**
- Investigation on the 7 Z(mm) events passing the WW selections is in the next slide

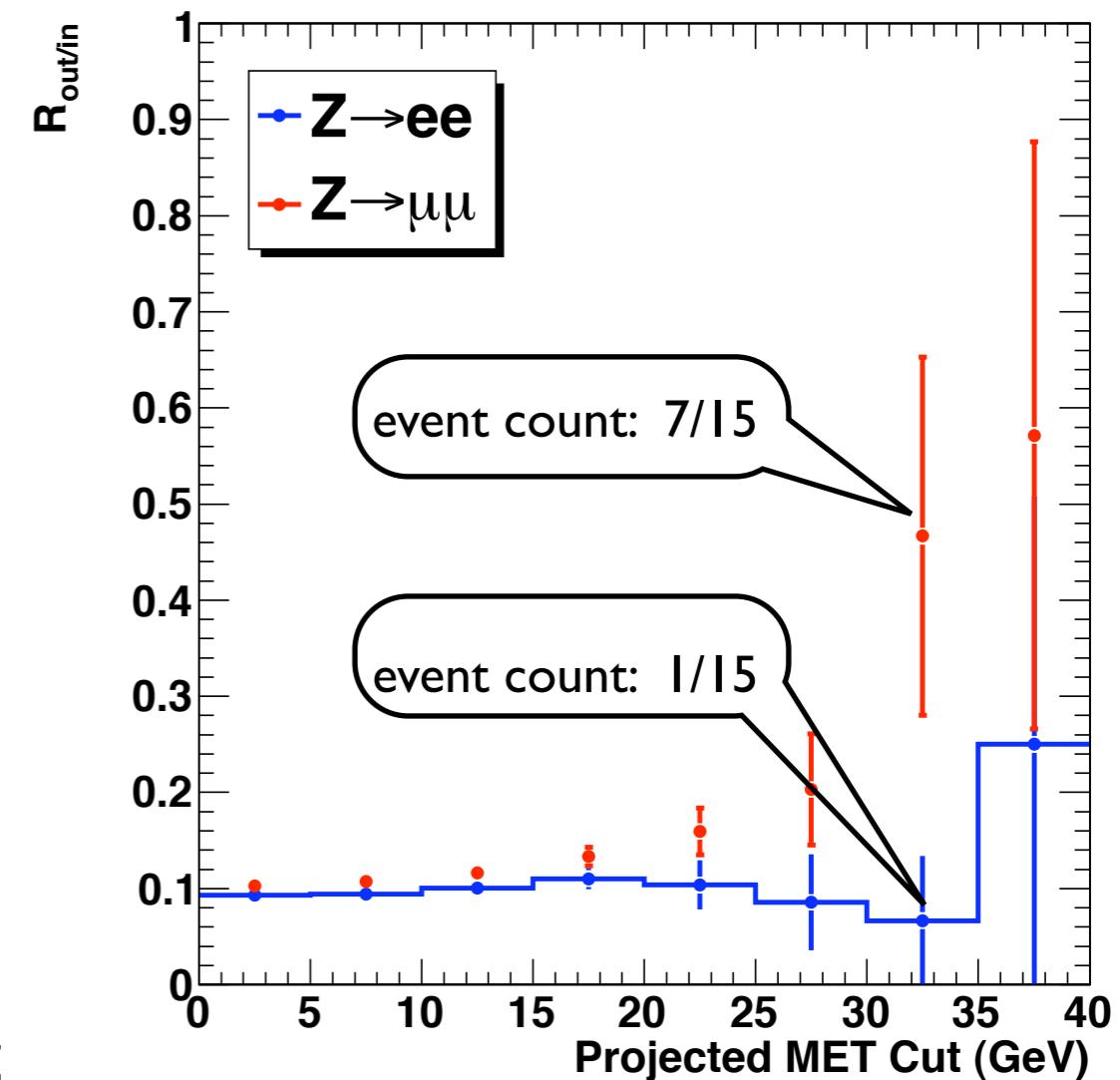
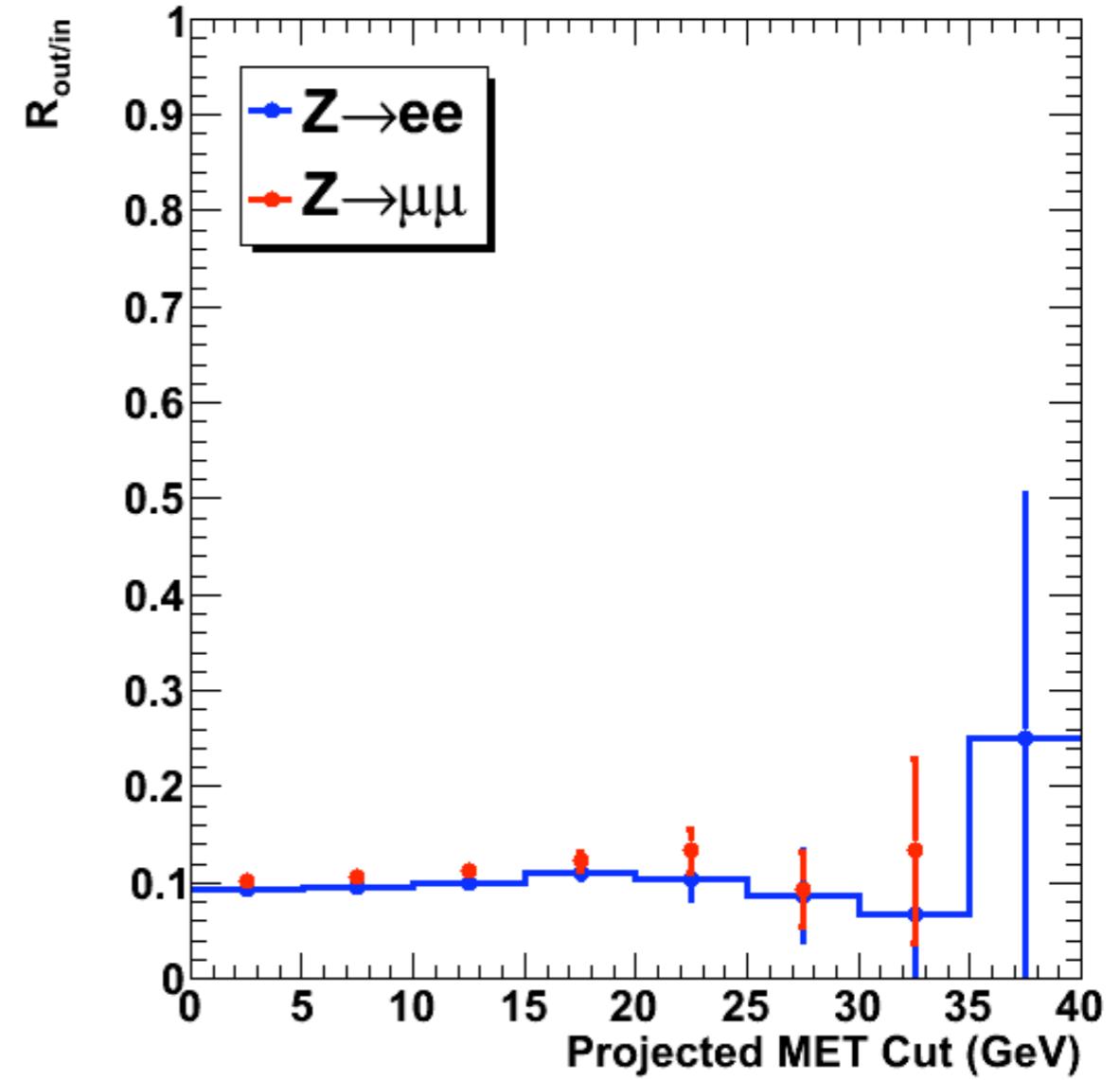


Table 1: Drell-Yan estimation with the nominal MET Cut.

Sample	ee	μμ
$R_{out/in}$	$0.07 \pm 0.07 \pm 0.04$	$0.47 \pm 0.18 \pm 0.36$
MC Prediction	$0.01 + 0.01$	$0.07 + 0.03$
Data Driven DY Estimate	$-0.03 \pm 0.04 \pm 0.03$	$0.18 \pm 0.55 \pm 0.57$
Actual Yield in Data	0	0

Investigation on the DY MM

- We check the 7 events passing $w\bar{w}$ selections, and see that 5 events contain muons with large σpT , such as 116.2 ± 50.0 , 80.5 ± 10.0
- Badly measured muons can easily push out the events outside the Z window (± 15 GeV)
- Selecting muons with additional $\sigma pT/pT < 0.1$ gets rid of the bad behavior in the $R_{out/in}$ ratio



Sample	ee	$\mu\mu$
$R_{out/in}$	$0.07 \pm 0.07 \pm 0.04$	$0.13 \pm 0.09 \pm 0.04$
MC Prediction	0.02 ± 0.02	0.02 ± 0.01
Data Driven DY Estimate	$-0.03 \pm 0.04 \pm 0.03$	$0.05 \pm 0.16 \pm 0.16$
Actual Yield in Data	0	0

DY estimate
with σpT cut

Signal/Background Check on cut $\sigma_{\text{pT}}/\text{pT} < 0.1$

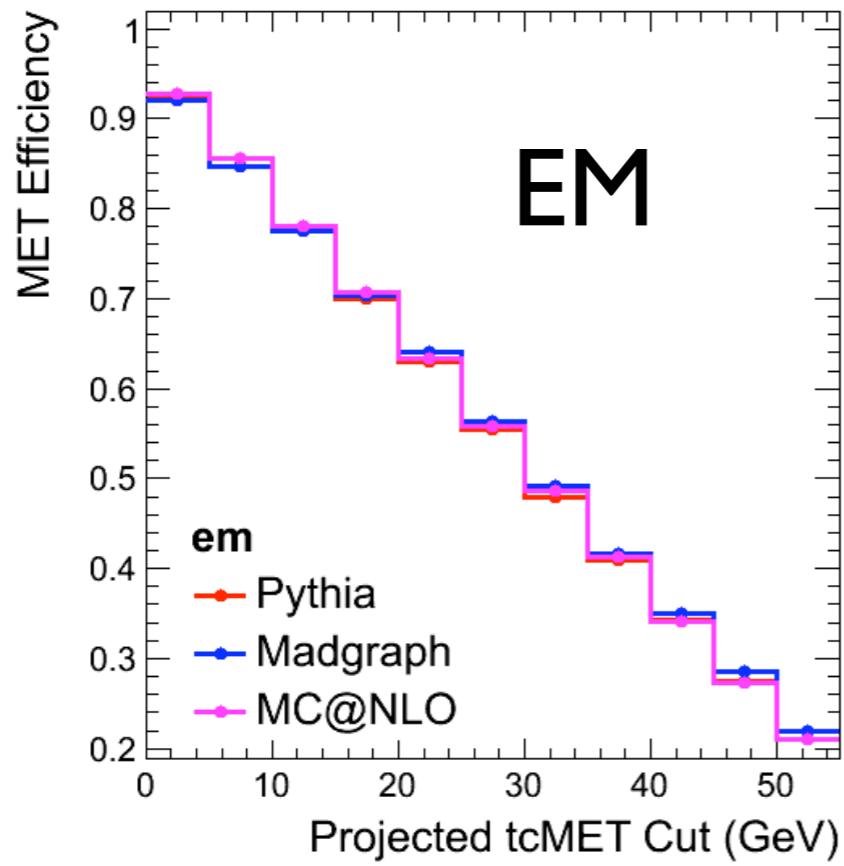
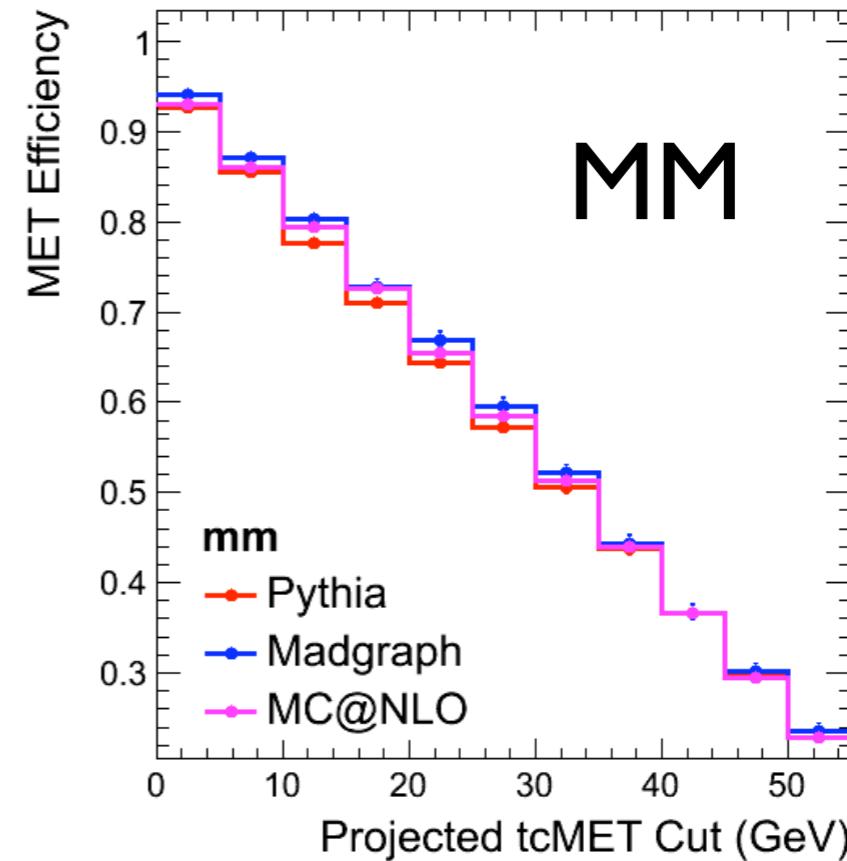
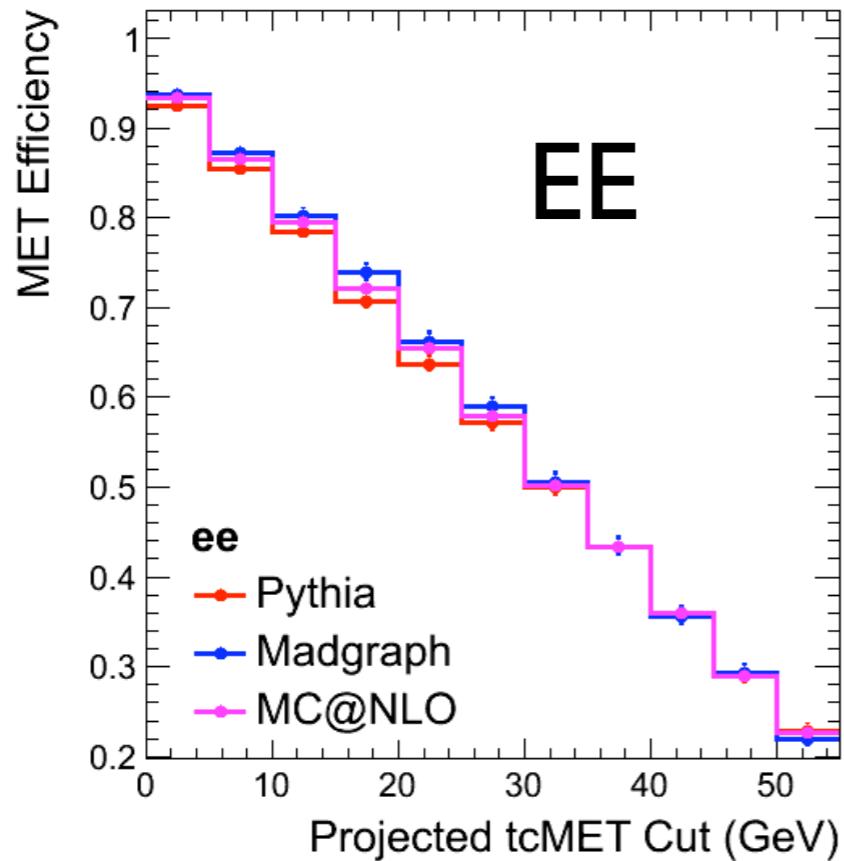
- With 36X MC
 - WW efficiency drops by 0.5%
 - Z(MM) MC background in MM channel is removed completely
 - The 100/pb estimation reduces from 0.14 ± 0.10 (2 events) to 0.
- With 38X MC (Note that the cuts are not synced to v1)
 - Z(MM) MC background in MM channel reduces by more than one half
 - 7 events reduces to 2 events
- We propose to add this cut to the reference V1

MET Signal Efficiency

MET Selection Efficiency

- The current selection is based on the projected MET
 - EE/MM: projected MET > 35 GeV
 - EM: projected MET > 20 GeV
- We have to rely purely on the MC for this measurement
 - NLO and beyond effects
 - compare various MCs and look at MCFM to check scaling uncert.
 - Data/MC MET resolution
 - Check this using Z-events
 - PU effect in the data
 - Embed WW MC with N random MET vectors from MinBias MC
 - MET efficiency vs N vertices, and see the effects

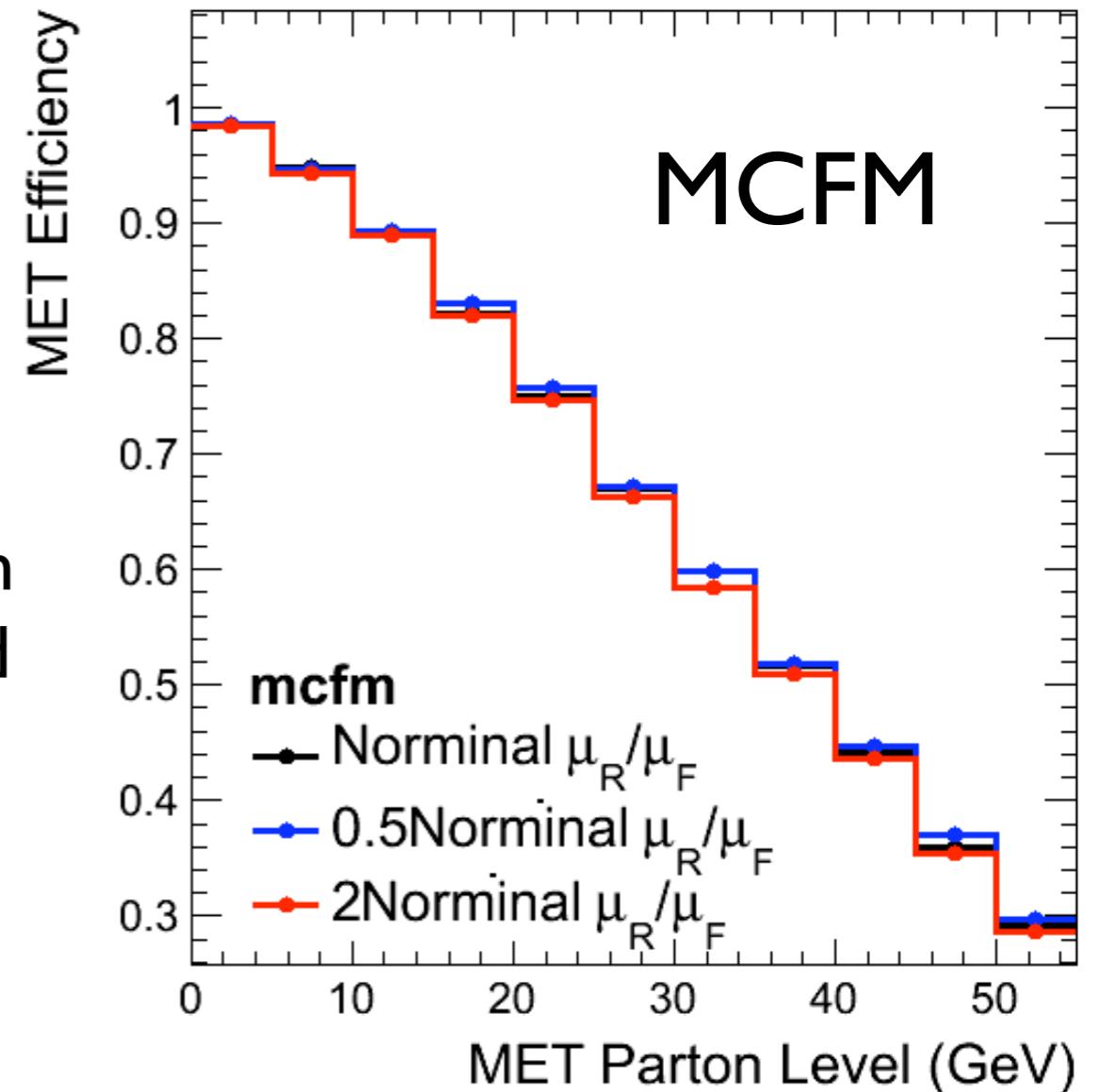
Met Efficiency from MCs



The largest relative difference between the 3 MC samples are 3% in MM, 1% in EE and EM with the reference VI selections

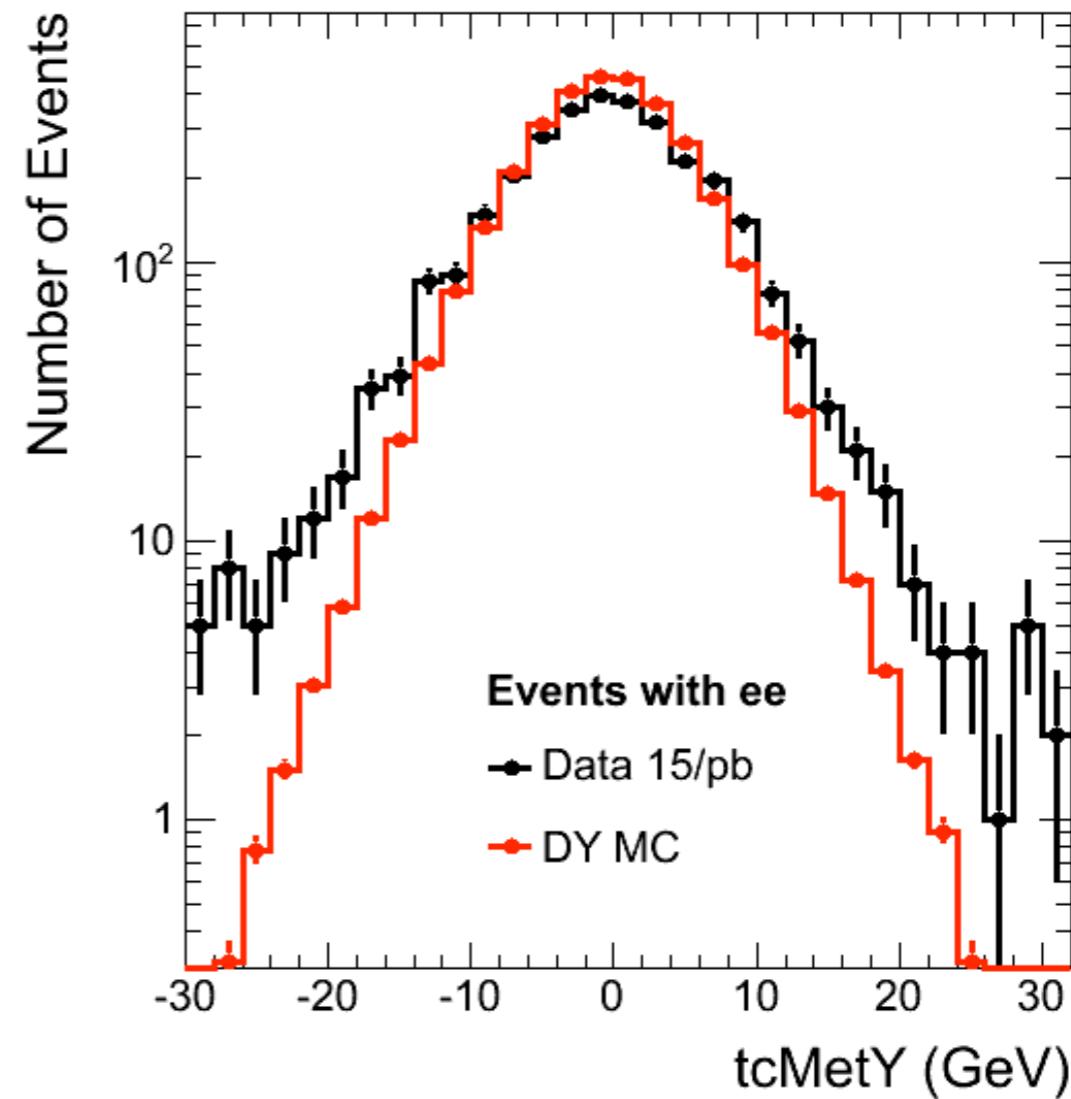
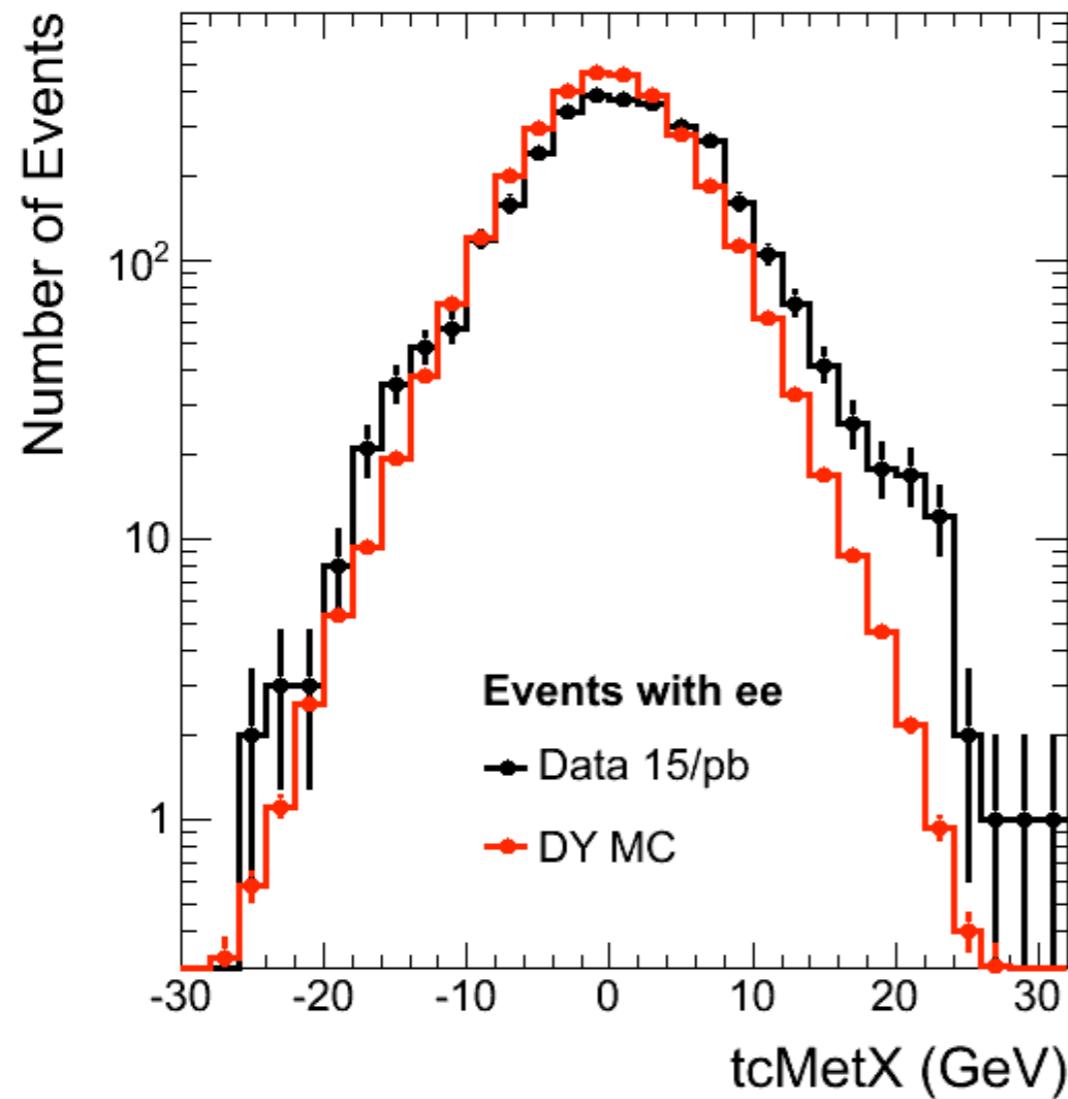
Met Efficiency from MCFM

- This is just a sanity check on the possible theoretical errors
 - The absolute number should not be directly compared with the values based on MC samples
 - Varying the normalization/factorization scale gives only a hint on the NLO and beyond effects
 - The relative difference is 2% at 35 GeV
 - Will repeat with more scaling variations



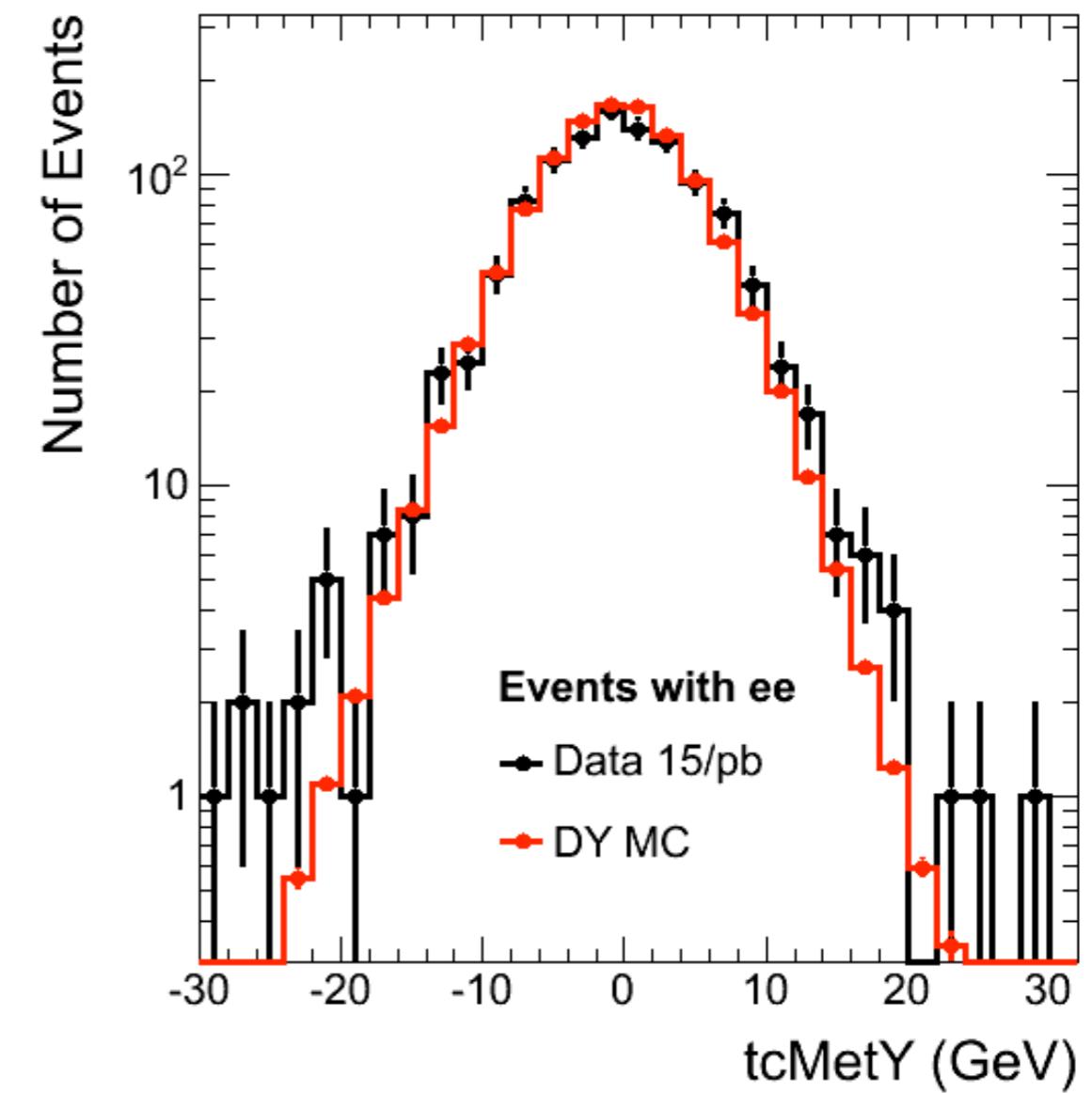
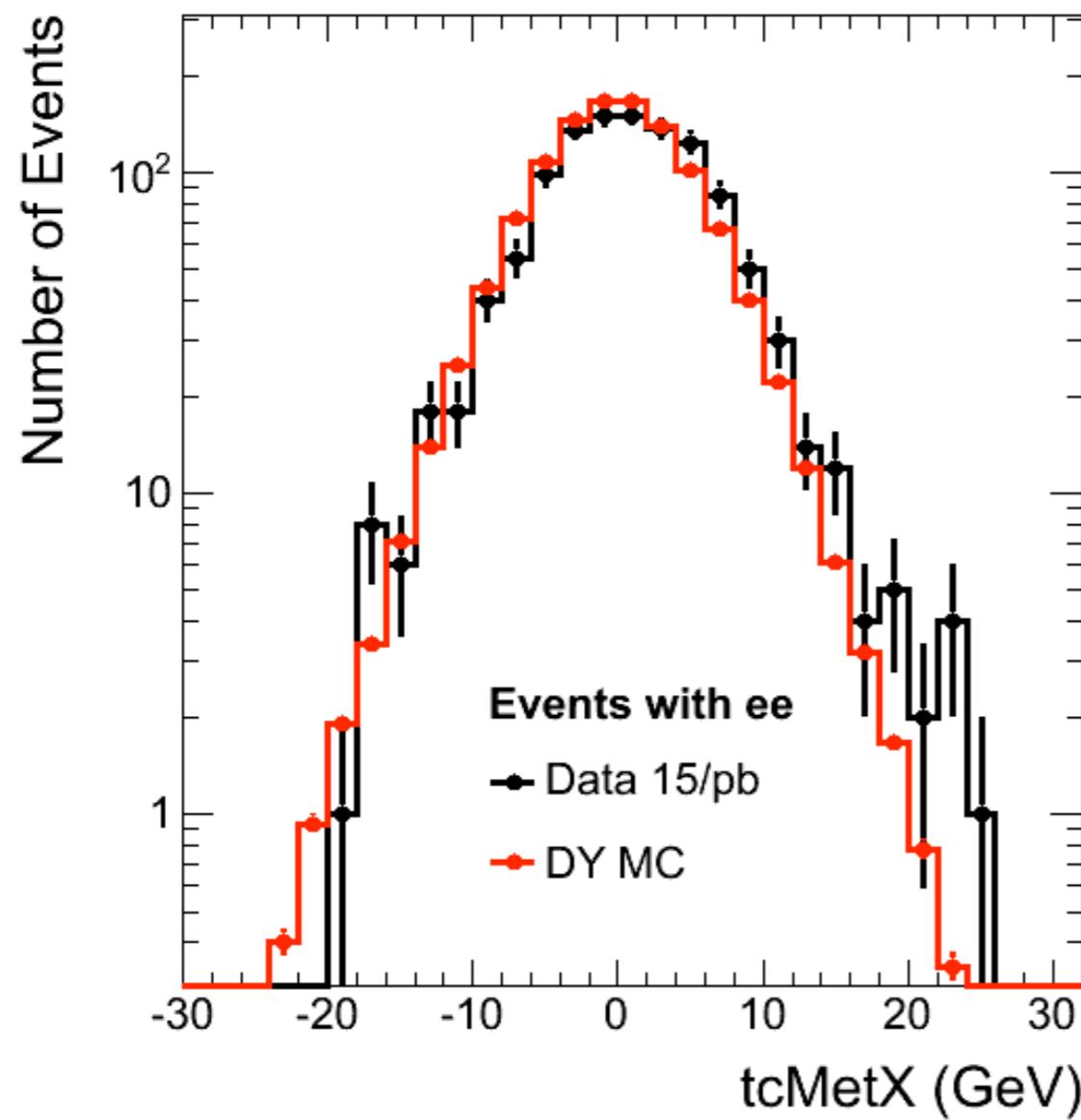
Data/MC MET Resolutions using Zs

- The resolution in data is wider than in MC, mainly to the PU
 - The data/MC difference introduces more systematic error on MET eff.
 - The PU effects to Z events could be different from the effects on WW
 - $Z \rightarrow \mu\mu$ results are in backup slides 21-22



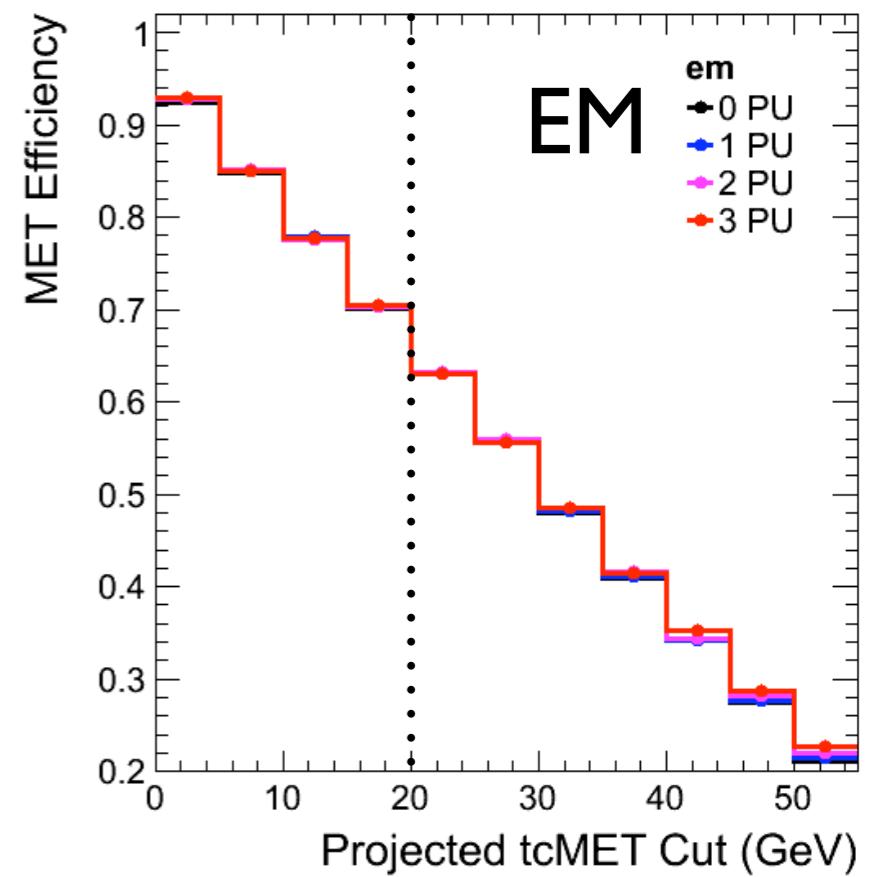
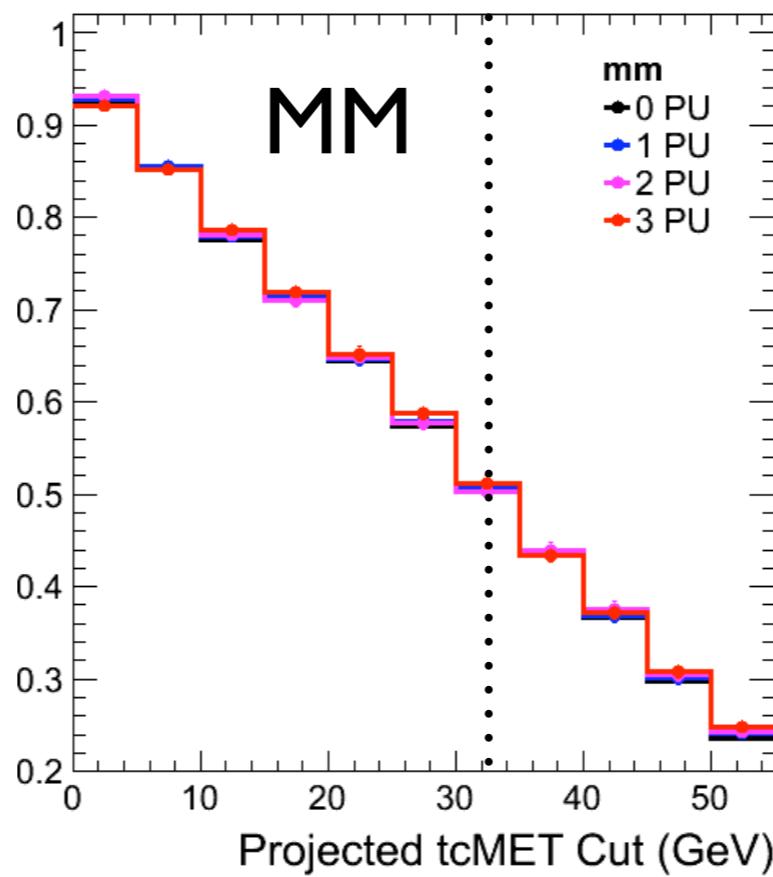
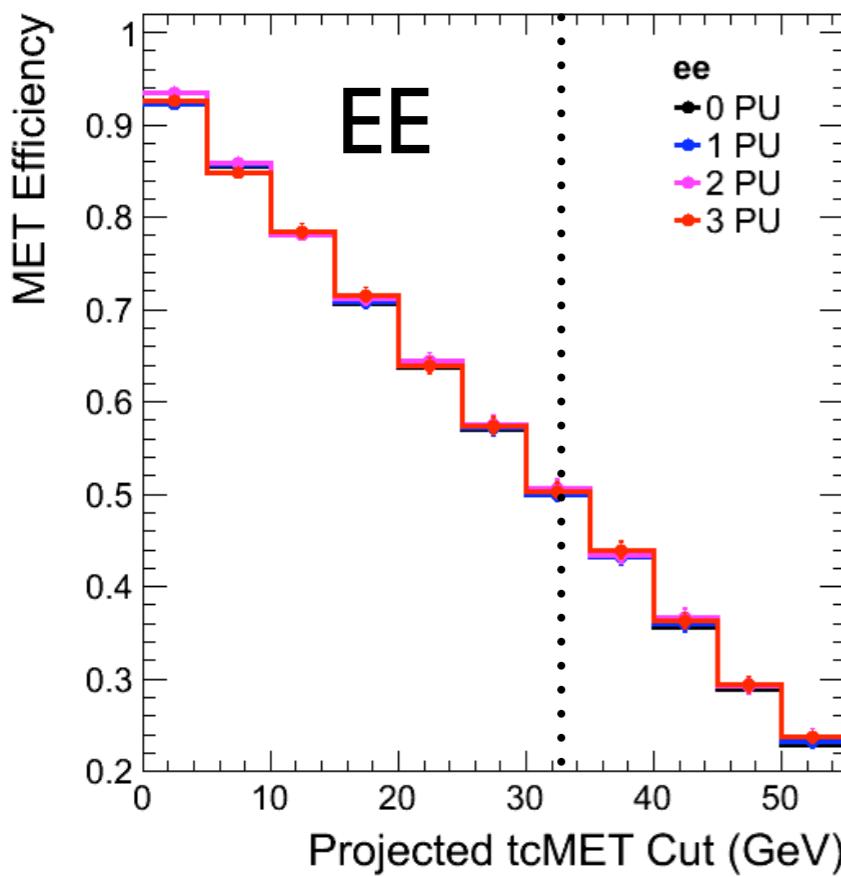
Data/MC MET Resolutions in One-Vertex Case

- Requiring only one good vertex in data
 - The resolution in data agrees much better with MC
 - PU effects are not negligible in comparing the met resolution



Convolute MinBias MET with WW MC

- Convolute the WW MC MET with N MinBias MET
 - For each WW event, add N random MinBias MET vectors (x,y)
 - Recompute the projected MET
 - “Closure test” on the Z MET in slide 23

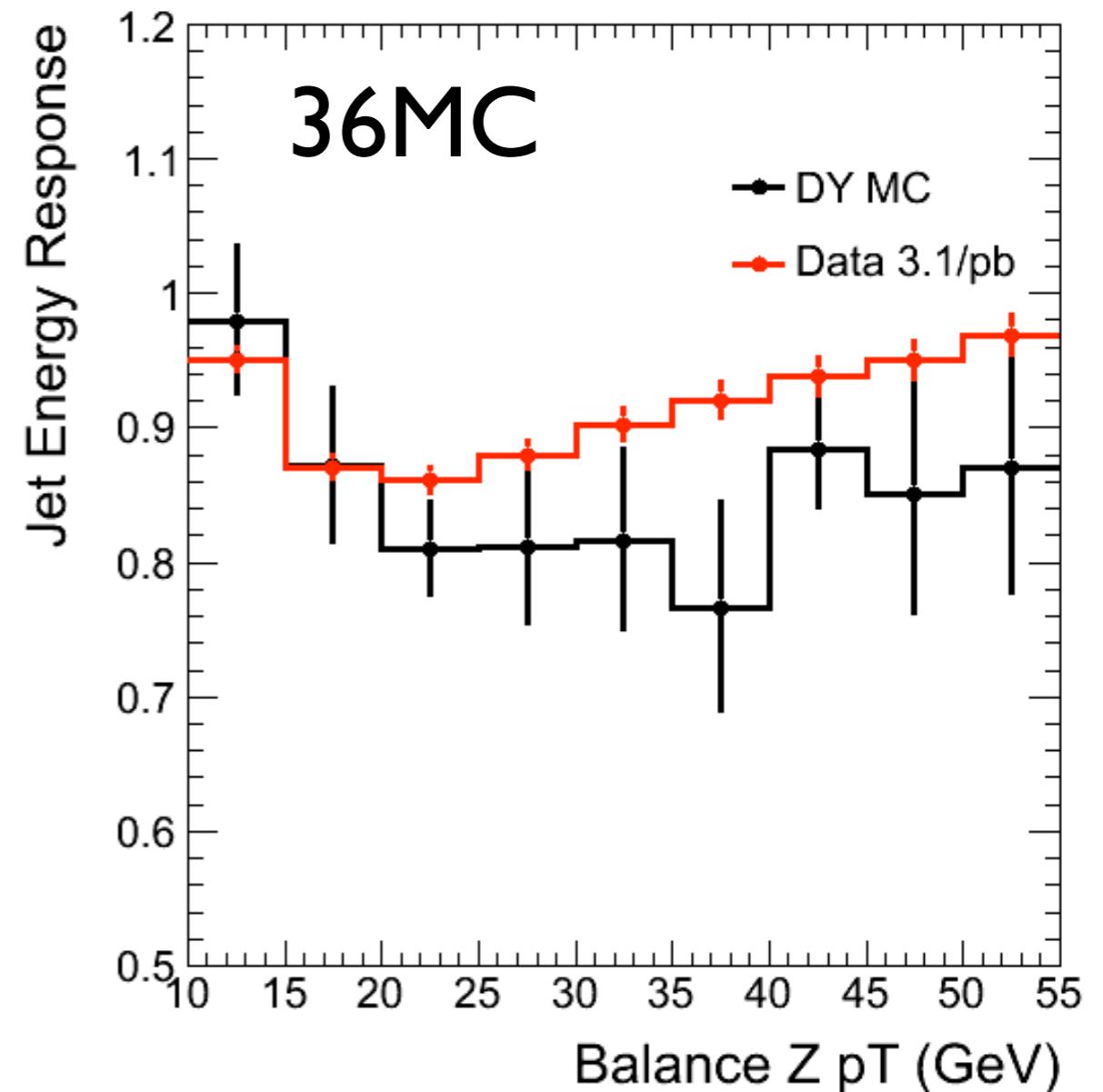
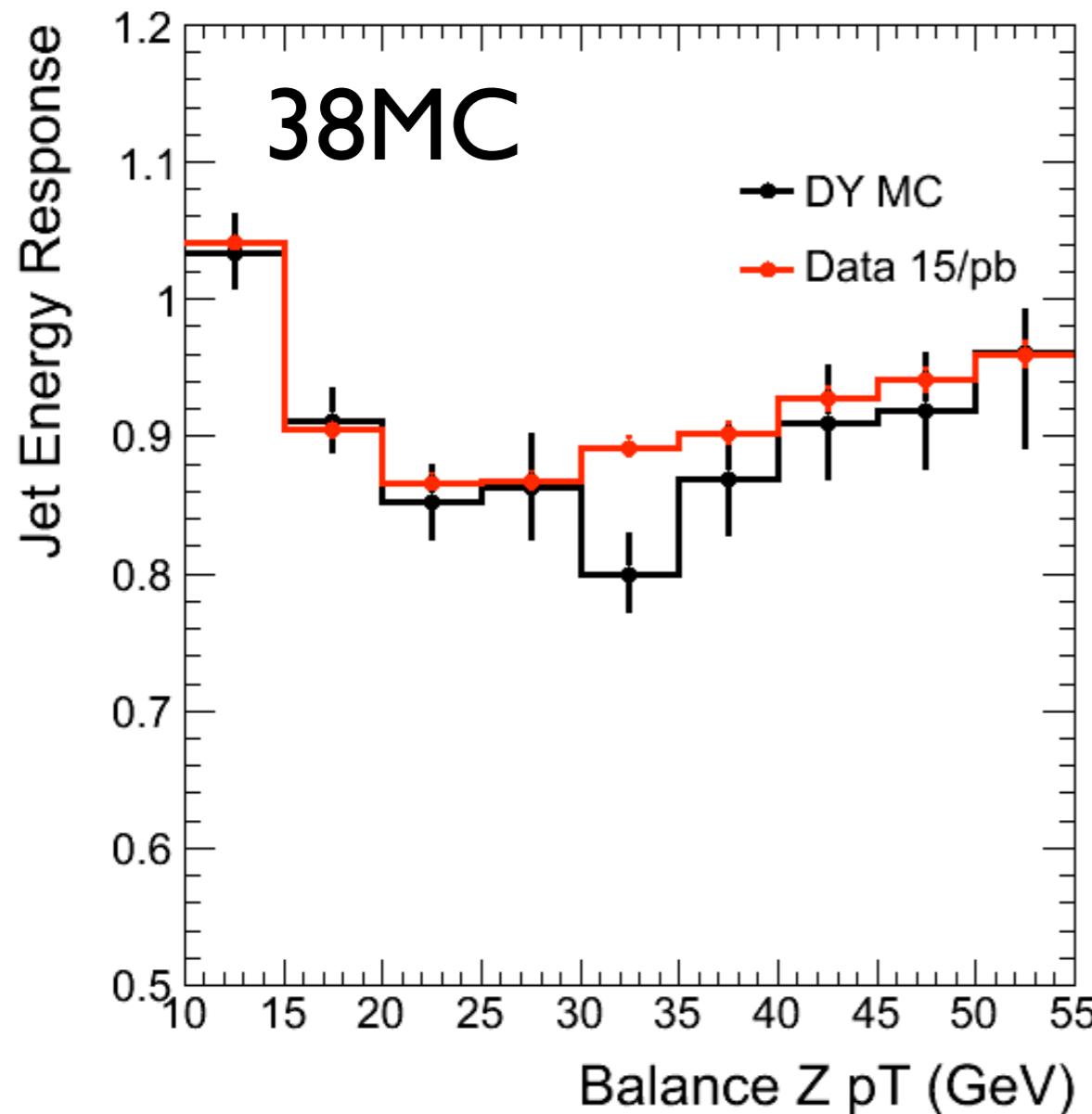


- The uncertainties to MET efficiency due to PU are negligible

JEC in 38X

JEC in 38X using Z + 1 Jet event

- JEC response: Corrected PFJet pT/ balance Z pT
 - Using 36X corrections on 38X data/MC gives good data/MC agreement
 - Event selections in backup slide 20



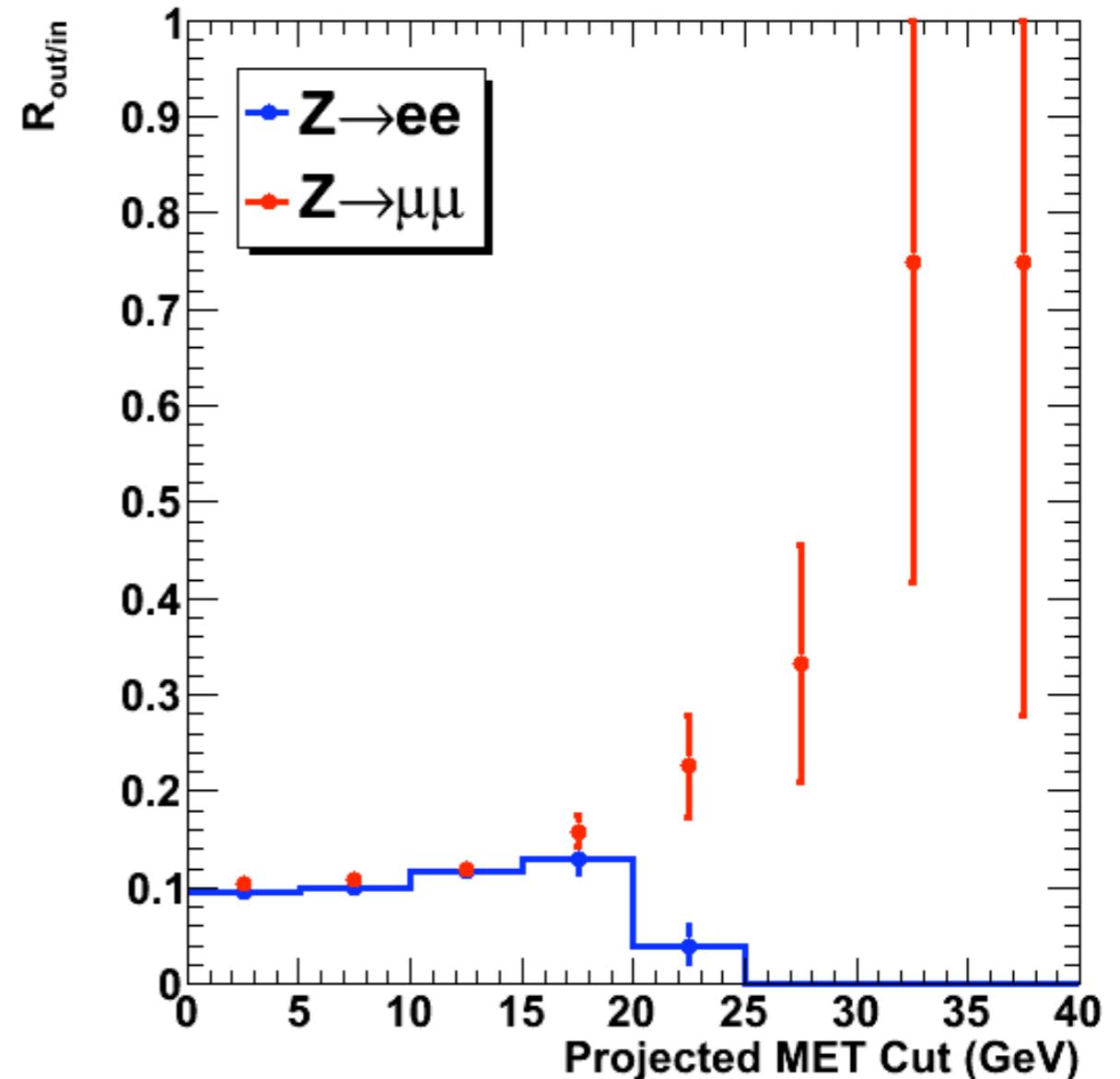
Summary

- We have a data-driven method to estimate DY background
 - $R(\text{out/in})$ is sensitive to MET cut. We found that muons with large σpT contribute > 50% to the $Z(\text{mm})$ events outside the Z window in MM.
 - Apply $\sigma pT/pT < 0.1$ cut on muons reduces $R(\text{out/in})$ systematic error
 - The $\sigma pT/pT < 0.1$ cut on muons reduces DY in MM significantly, while the signal efficiency drop is < 0.5%. We propose to add this to VI.
 - With σpT cut, we expect $0.0 \pm 0.0 \pm 0.0$ (EE) $0.1 \pm 0.2 \pm 0.2$ (MM) Drell-Yan Bkg
- MET selection efficiencies on WW
 - Differences between Pythia/Madgraph/MC@NLO are within 3%
 - MET resolution (X,Y) are sensitive to the PU, seen in Z events
 - However, PU effects to WW MET efficiency are negligible
- Applying 36X corrections on 38X data/MC gives good data/MC agreement, using the L2/L3 PF Jets

Backup Slides

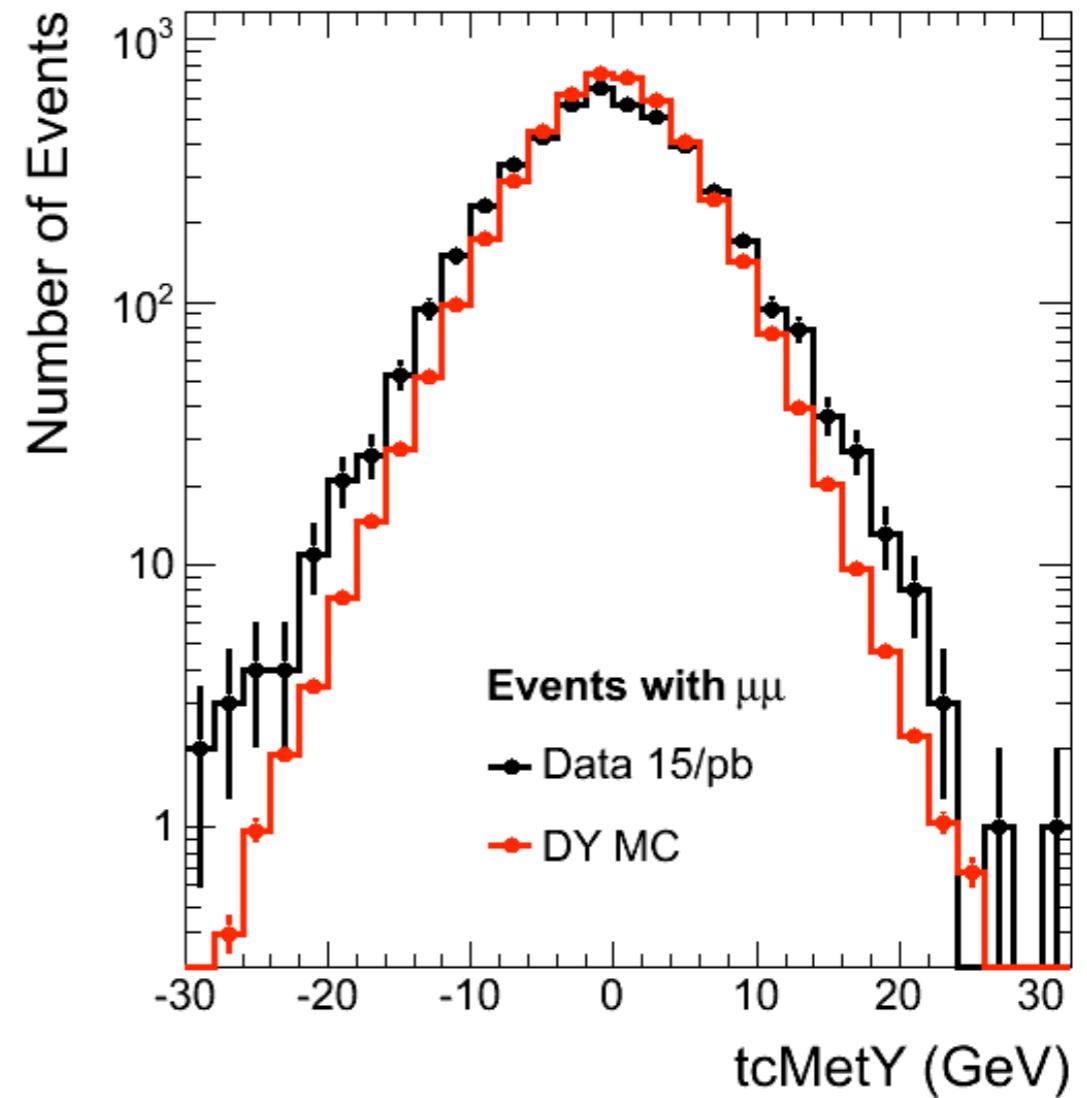
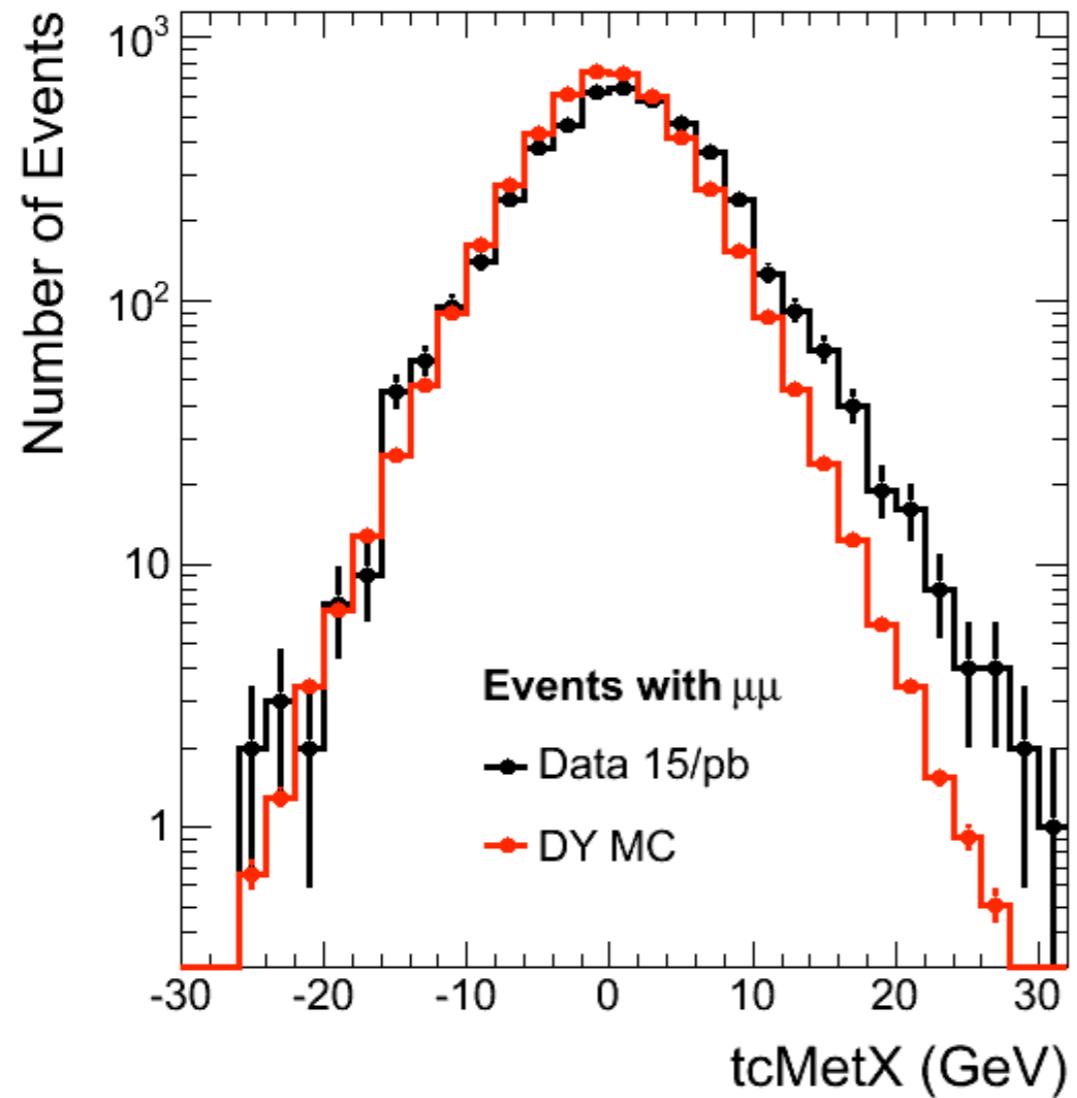
R(out/in) Using PFMet

- Cross check the R(out/in) dependence on MET cut using the PF Met
- Similar behavior as in the case using tcMET



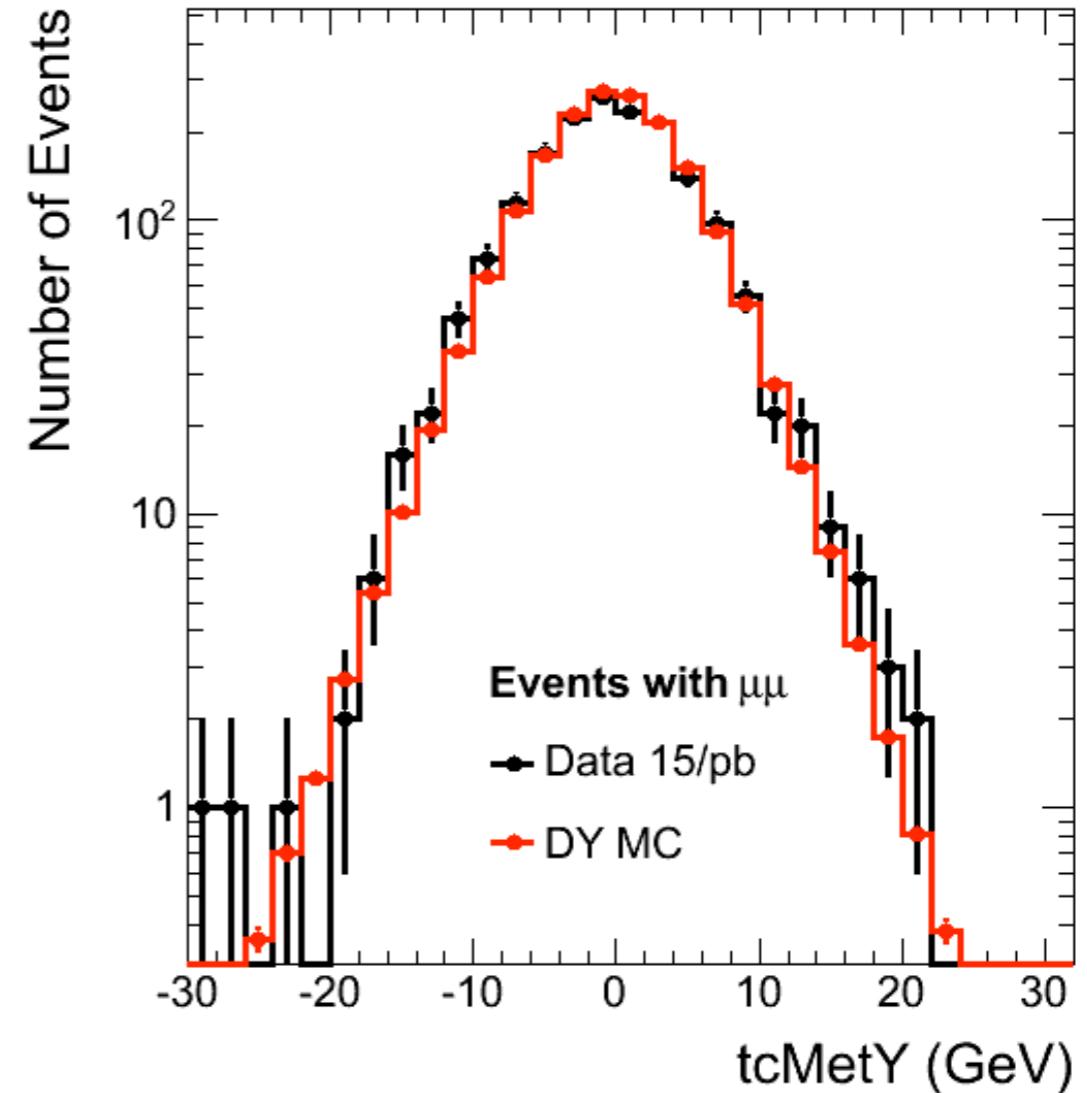
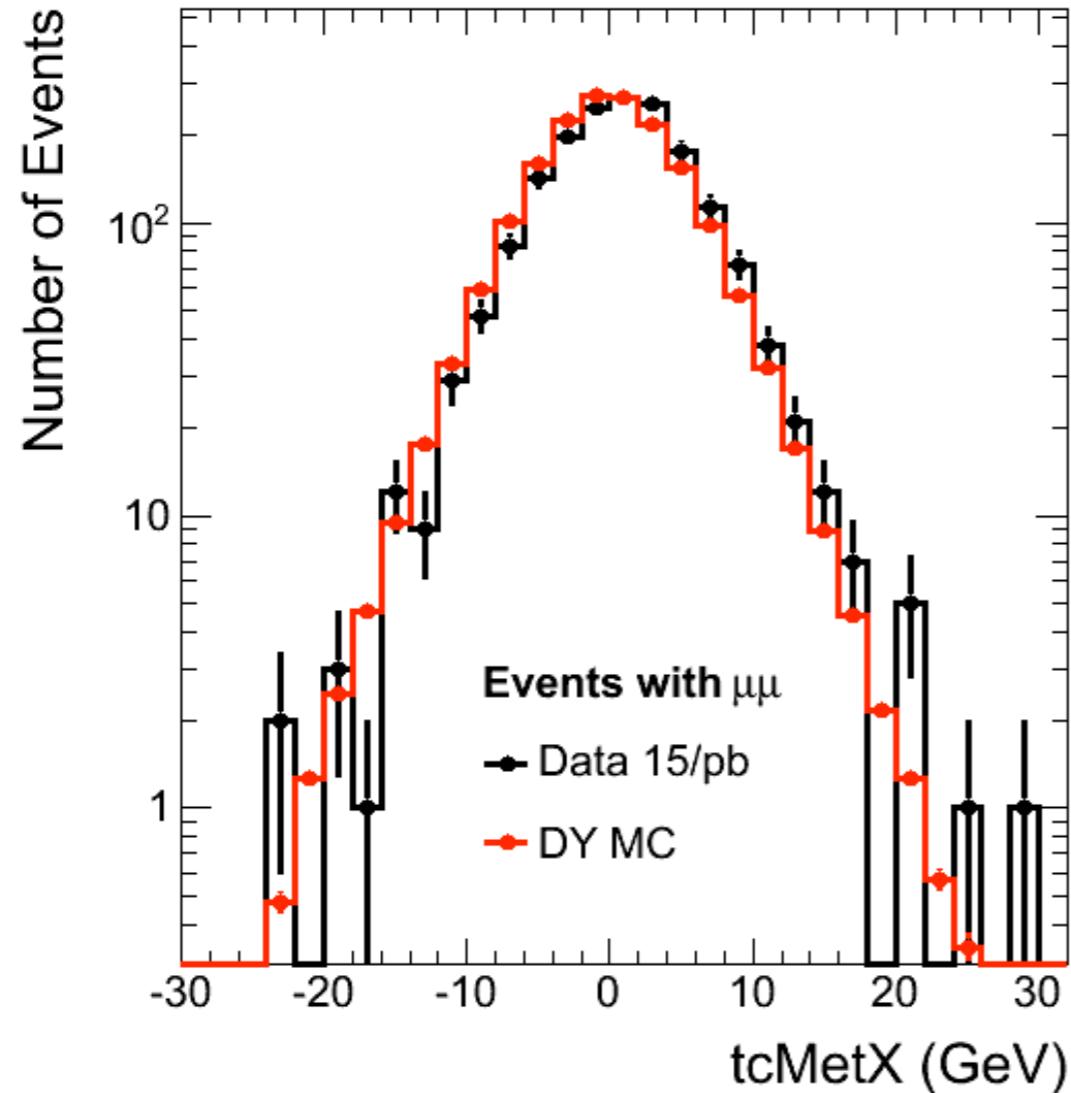
MET (x,y) in MM

- Events with all number of vertices



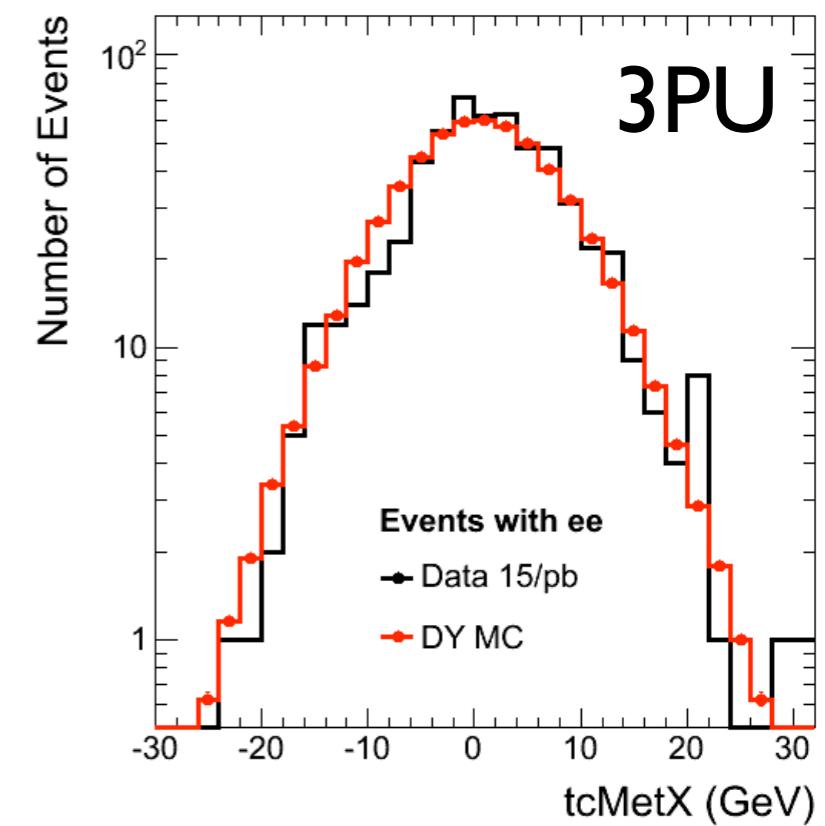
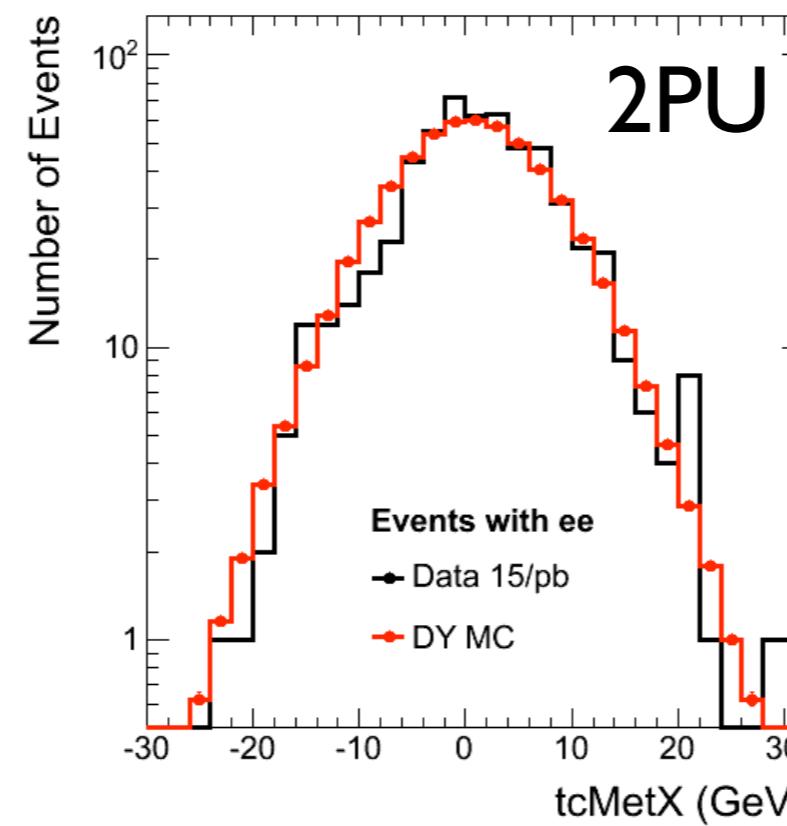
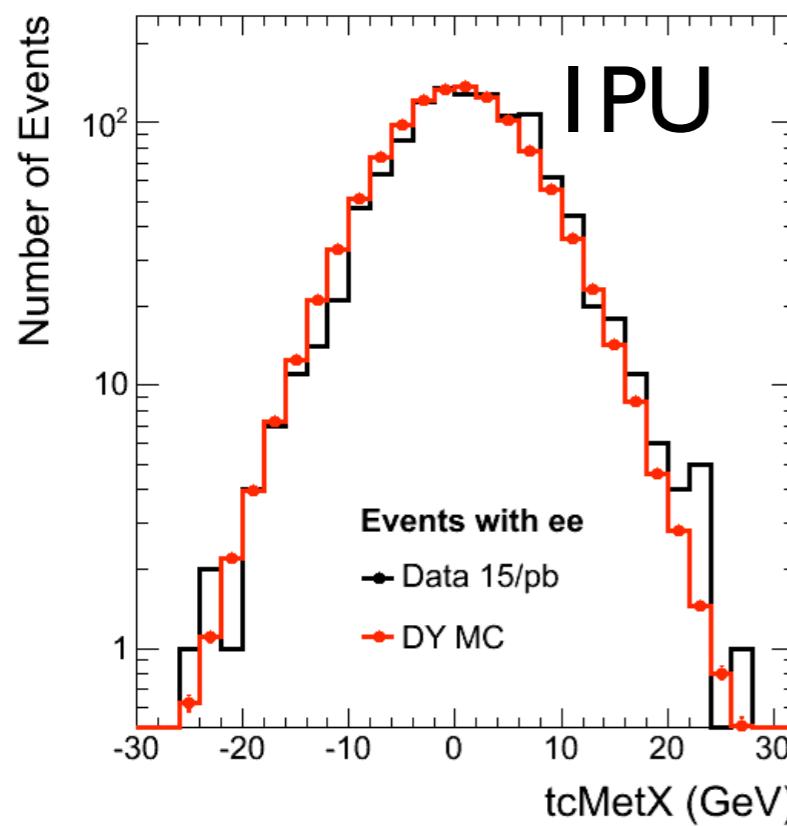
MET (x,y) in MM One-Vertex

- Require only one good vertex in Data



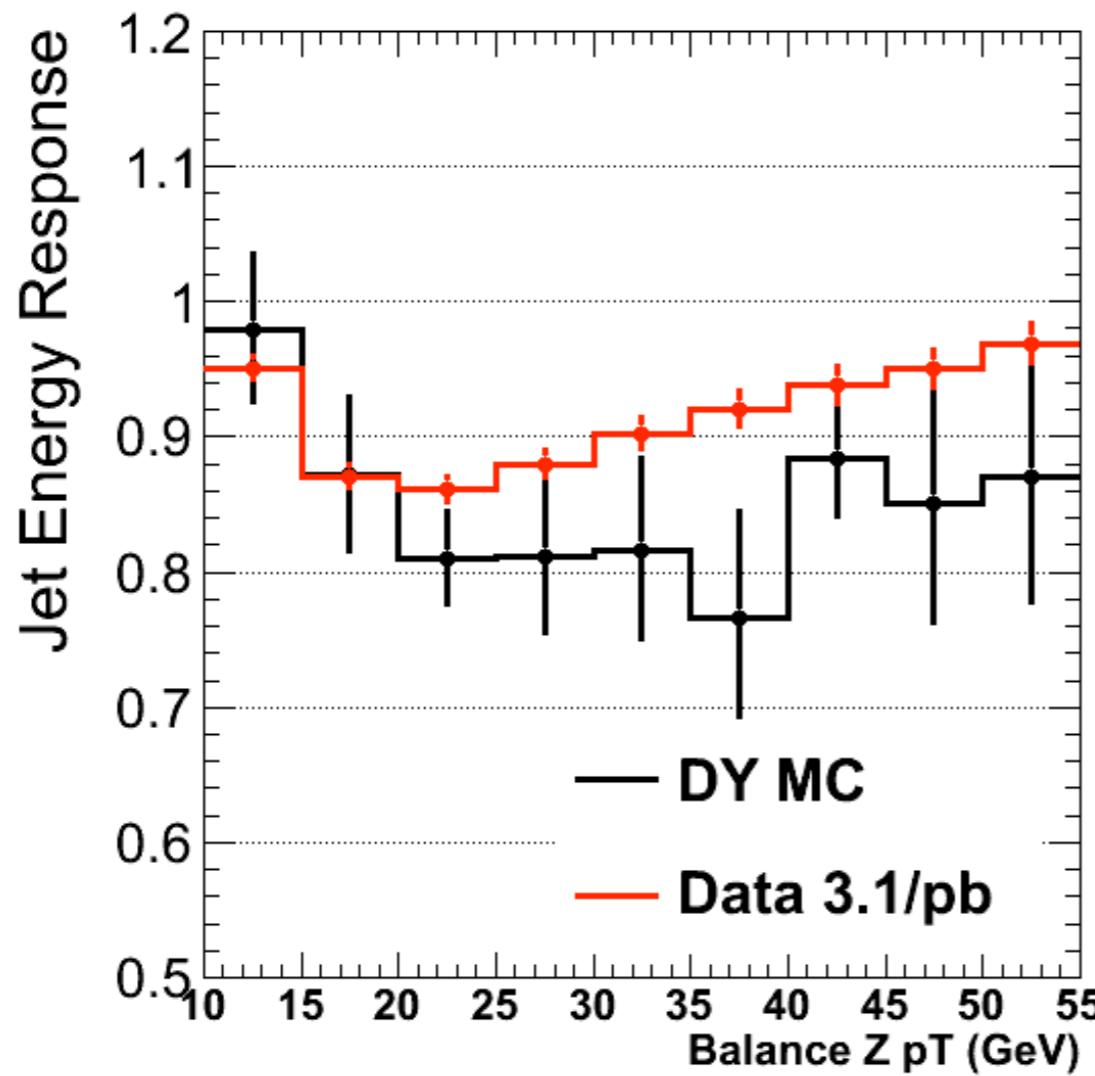
Closure Test of MinBias Embedding on Z

- Compare the Met (x,y) with PU between the data and the MinBias embedded Z MC
 - The width look consistent



Jet Energy Correction Using Z Balance (36X)

- The standard L2L3 JEC is derived for high pT jets, we need to cross-check the corrections in the region (20-30) GeV
- For this validation, we use Z+I Jet events, with the selections,
 - $|\Delta\Phi(\text{leading jet-diLepton}) - \pi| < 0.2$
 - Other jets in the event with $pT < 0.1 * \text{leading jet } pT$
- The jet response is defined as corrected leading jet pT / dilepton pT



1. There is an overall systematic difference in data vs MC, however data is statistically limited
2. Similar conclusion is found from γ Jets study, Francesco Pandolfi <http://indico.cern.ch/getFile.py/access?contribId=0&resId=0&materialId=slides&confId=108390>
3. Assume the 7% at 25GeV is real, we get ~2-3% additional uncertainty from JEC, this needs to be checked with more data